



The Proceedings
OF
THE INSTITUTION OF
ELECTRICAL ENGINEERS

FOUNDED 1871: INCORPORATED BY ROYAL CHARTER 1921

ISSUED IN THREE PARTS AS FOLLOWS:

Part A. POWER ENGINEERING (*February, April, etc.*)

Part B. RADIO AND ELECTRONIC ENGINEERING (INCLUDING COMMUNICATION ENGINEERING)
(*January, March, etc.*)

Part C. INSTITUTION MONOGRAPHS (*March and September only*)

PART B

RADIO AND ELECTRONIC ENGINEERING
(INCLUDING COMMUNICATION ENGINEERING)

VOLUME 104, 1957

PUBLISHED BY THE INSTITUTION, SAVOY PLACE, LONDON, W.C.2

The Institution of Electrical Engineers

FOUNDED 1871

INCORPORATED BY ROYAL CHARTER 1921

PATRON: HER MAJESTY THE QUEEN

COUNCIL 1956-1957

President

SIR GORDON RADLEY, K.C.B., C.B.E., Ph.D.(Eng.).

Past-Presidents

SIR JAMES SWINBURNE, Bart., F.R.S.
W. H. ECCLES, D.Sc., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGUMBE, T.D.
J. M. DONALDSON, M.C.
PROFESSOR E. W. MARCHANT, D.Sc.
H. T. YOUNG.
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng., LL.D.
J. R. BEARD, C.B.E., M.Sc.
SIR NOEL ASHBRIDGE, B.Sc.(Eng.).
COLONEL SIR A. STANLEY ANGWIN, K.C.M.G., K.B.E., D.S.O.,
M.C., T.D., D.Sc.(Eng.).

SIR HARRY RAILING, D.Eng.
P. DUNSHEATH, C.B.E., M.A., D.Sc.(Eng.).
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROFESSOR E. B. MOULLIN, M.A., Sc.D.
SIR ARCHIBALD J. GILL, B.Sc.(Eng.).
SIR JOHN HACKING.
COLONEL B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.Sc.(Eng.).
SIR JOSIAH ECCLES, C.B.E., D.Sc.
SIR GEORGE H. NELSON, Bart.

Vice-Presidents

T. E. GOLDUP, C.B.E.
S. E. GOODALL, M.Sc.(Eng.).
WILLIS JACKSON, D.Sc., D.Phil., Dr.Sc.Tech., F.R.S.

G. S. C. LUCAS, O.B.E.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D.,
B.Sc.

Honorary Treasurer

THE RT. HON. THE VISCOUNT FALMOUTH.

Ordinary Members of Council

PROFESSOR H. E. M. BARLOW, Ph.D., B.Sc.(Eng.).
J. BENNETT.
J. A. BROUGHALL, B.Sc.(Eng.).
C. M. COCK.
A. R. COOPER, M.Eng.
B. DONKIN, B.A.
PROFESSOR J. GREIG, M.Sc., Ph.D.
E. M. HICKIN.
F. J. LANE, O.B.E., M.Sc.
D. McDONALD, B.Sc.
C. T. MELLING, C.B.E., M.Sc.Tech.

H. H. MULLENS, B.Sc.
A. H. MUMFORD, O.B.E., B.Sc.(Eng.).
W. F. PARKER.
D. P. SAYERS, B.Sc.
G. L. WATES, J.P.
H. WATSON-JONES, M.Eng.
D. B. WELBOURN, M.A.
H. WEST, M.Sc.
J. H. WESTCOTT, B.Sc.(Eng.), Ph.D.
E. L. E. WHEATCROFT, M.A.

Chairmen and Past-Chairmen of Sections

Measurement and Control:

D. TAYLOR, M.Sc., Ph.D.
*W. BAMFORD, B.Sc.

Radio and Telecommunication:

R. C. G. WILLIAMS, Ph.D., B.Sc.(Eng.).
*H. STANESBY.

Supply:

P. J. RYLE, B.Sc.(Eng.).
*L. DRUCQUER.

Utilization:

H. J. GIBSON, B.Sc.
*D. B. HOGG, M.B.E., T.D.

Chairmen and Past-Chairmen of Local Centres

East Midland Centre:

H. L. HASLEGRAVE, M.A., Ph.D., M.Sc.
(Eng.).
*F. R. C. ROBERTS.

Mersey and North Wales Centre:

P. D'E. STOWELL, B.Sc.(Eng.).
*PROFESSOR J. M. MEEK, D.Eng.

North Midland Centre:

W. K. FLEMING.
*F. BARRELL.

North-Eastern Centre:

J. CHRISTIE.
*A. H. KENYON.

North-Western Centre:

T. E. DANIEL, M.Eng.
*G. V. SADLER.

Northern Ireland Centre:

DOUGLAS S. PARRY.
*MAJOR E. N. CUNLIFFE, B.Sc.Tech.

Western Centre:

PROFESSOR G. H. RAWCLIFFE, M.A., D.Sc.
*T. G. DASH, J.P.

* Past Chairman.

Scottish Centre:

PROFESSOR F. M. BRUCE, M.Sc., Ph.D.
*E. WILKINSON, Ph.D., B.Eng.

South Midland Centre:

C. J. O. GARRARD, M.Sc.
*H. S. DAVIDSON, T.D.

Southern Centre:

H. ROBSON, B.Sc.
*L. H. FULLER, B.Sc.(Eng.).

Secretary

W. K. BRASHER, C.B.E., M.A., M.I.E.E.

Assistant Secretary

F. C. HARRIS.

Deputy Secretary

F. JERVIS SMITH, M.I.E.E.

Editor-in-Chief

G. E. WILLIAMS, B.Sc.(Eng.), M.I.E.E.

CONTENTS

VOL. 104, Part B

1957

	PAGE		PAGE
The President's Inaugural Address. Sir Gordon Radley, K.C.B., C.B.E., Ph.D.(Eng.)	1	Laboratory Test Equipment for Synchronous Regenerative Radiotelegraph Systems. C. G. Hilton, H. B. Law, B.Sc.Tech., F. J. Lee and F. A. W. Levett	141
Discussion (<i>communicated</i>) on 'An X-Band Magnetron Q-Measuring Apparatus' (Paper by J. R. G. Twisleton)	6	Discussion on the above six papers before the Radio and Telecommunication Section	147
Chairmen's Addresses:		High-Temperature Properties of Tungsten which influence Filament Temperatures, Lives and Thermionic-Emission Densities. R. N. Bloomer	153
Measurement and Control Section. Denis Taylor, M.Sc., Ph.D.	7	A Survey of Factors limiting the Performance of Magnetic Recording Systems. E. D. Daniel, M.A., P. E. Axon, O.B.E., M.Sc., Ph.D., and W. T. Frost	158
Radio and Telecommunication Section. R. C. G. Williams, Ph.D., B.Sc.(Eng.)	15	A Theoretical Study of Propagation along Tape Ladder Lines. P. N. Butcher, Ph.D.	169
North-Eastern Radio and Measurement Group. A. E. Twycross	68	The Coupling Impedance of Tape Structures. P. N. Butcher, Ph.D.	177
Scottish Centre. Prof. F. M. Bruce, M.Sc., Ph.D.	81	Discussion (<i>communicated</i>) on 'Servo-Operated Recording Instruments' (Paper by A. J. Maddock)	187
South Midland Centre. C. J. O. Garrard, M.Sc.	83	A Coaxial Standing-Wave Detector for the S-Band. L. W. Shawe, B.Sc., and G. W. Fynn	188
Ship Stabilization: Automatic Controls, Computed and in Practice. J. Bell, M.Sc.	20	An S-Band Coaxial Load. L. W. Shawe, B.Sc.	191
The Radiating Properties of End-Fire Aerials. J. Brown, M.A., Ph.D., and J. O. Spector, Ph.D.	27	A Resonant-Cavity Filter for the S-Band. A. A. L. Browne, B.Sc.	193
A Non-Resonant Waveguide Window. A. E. Barrington, Ph.D., B.Sc.(Eng.), and J. T. Hyman, B.Sc.(Eng.)	35	Discussion (<i>communicated</i>) on 'A Development of the Collard Principle of Articulation Calculation' (Paper by D. L. Richards and R. B. Archbold)	196
Fading of Long-Distance Radio Signals and a Comparison of Space- and Polarization-Diversity Reception in the 6-18 Mc/s Range. G. L. Grisdale, Ph.D., J. G. Morris, B.Sc., and D. S. Palmer, M.A.	39	Discussion on 'The Crystal Palace Television Transmitting Station' (Paper by F. C. McLean, A. N. Thomas and R. A. Rowden), as follows:	
Discussion (<i>communicated</i>)	341	Communicated remarks	197
Frequency-Modulation Distortion in Linear Networks. R. F. Brown, B.Eng.	52	Before the South Midland Centre and the Northern Ireland Centre	392
Discussion (<i>communicated</i>)	264	Discussion (<i>communicated</i>) on 'Band I Television-Transmitter Design, with particular reference to the Transmitters at Crystal Palace' (Paper by V. J. Cooper and W. J. Morcom)	197
The Erosion of Electrical Contacts by the Normal Arc. W. B. Ittner, III, Ph.D., and H. B. Ulsh, M.A.	63	Differences of Opinion about Dimensions. Prof. R. O. Kapp, B.Sc.(Eng.)	198
Discussion on 'Electrical and Magnetic Measurements in an Electrical Engineering Factory' (Paper by D. Edmundson), before the North-Eastern Radio and Measurement Group; the Mersey and North Wales Centre; and the South Midland Centre	69	Discussion before The Institution	205
Discussion (<i>communicated</i>) on 'An Investigation into some Fundamental Properties of Strip Transmission Lines with the Aid of an Electrolytic Tank' (Paper by J. M. C. Dukes)	72	Long-Distance Propagation at 94.35 Mc/s over the North Sea. R. A. Rowden, B.Sc.(Eng.), and J. W. Stark	210
Very-Low-Frequency Propagation and Direction-Finding. F. Horner, M.Sc.	73	The B.B.C. Sound Broadcasting Service on Very High Frequencies. E. W. Hayes and H. Page, M.Sc.	213
Acoustics of Large Orchestral Studios and Concert Halls. T. Somerville, B.Sc., and C. L. S. Gilford, M.Sc.	85	Frequency-Modulated V.H.F. Transmitter Technique. A. C. Beck, B.Sc.(Eng.), F. T. Norbury and J. L. Storr-Best, B.Sc.(Eng.)	225
Discussion (<i>communicated</i>)	597	Frequency-Modulated Quartz Oscillators for Broadcasting Equipment. W. S. Mortley	239
Frequency Diversity in the Reception of Selectively Fading Binary Frequency-Modulated Signals. J. W. Allnatt, B.Sc.(Eng.), E. D. J. Jones and H. B. Law, B.Sc.Tech.	98	Discussion on the above three papers before the Radio and Telecommunication Section	249
An Investigation of the Spectra of Binary Frequency-Modulated Signals with various Build-up Waveforms. J. W. Allnatt, B.Sc.(Eng.), and E. D. J. Jones	111	Propagation Characteristics of Low-Loss Tubular Waveguides. Prof. H. E. M. Barlow, Ph.D., B.Sc.(Eng.), and H. G. Effemey	254
An Improved Fading Machine. H. B. Law, B.Sc.Tech., F. J. Lee, R. C. Looser, B.Sc.(Eng.), and F. A. W. Levett	117	A New Form of Hybrid Junction for Microwave Frequencies. P. D. Lomer, M.Sc., and J. W. Crompton, B.E.	261
The Signal/Noise Performance Rating of Receivers for Long-Distance Synchronous Radiotelegraph Systems using Frequency Modulation. H. B. Law, B.Sc.Tech.	124	Bandwidth Compression of a Television Signal. G. G. Gouriet	265
The Detectability of Fading Radiotelegraph Signals in Noise. H. B. Law, B.Sc.Tech.	130		

	PAGE		PAGE
A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators. R. B. R.-Shersby-Harvie, B.A., L. B. Mullett, B.Sc., W. Walkinshaw, M.A., J. S. Bell, B.Sc., and B. G. Loach, B.Sc.	273	Discussion on the above two papers before a Joint Meeting of the Measurement and Control Section and the Supply Section, in conjunction with the British Nuclear Energy Conference	447
Discussion before a Joint Meeting of the Measurement and Control Section and the Radio and Telecommunication Section	290	A Cyclotron for Medical Research. J. W. Gallop, B.Sc.(Eng.), D. D. Vonberg, B.Sc.(Eng.), R. J. Post, W. B. Powell, M.A., J. Sharp, B.Sc.(Eng.), and P. J. Waterton, B.Sc.(Eng.)	452
Junction-Transistor Bootstrap Linear-Sweep Circuits. K. P. P. Nambiar, B.Sc., and A. R. Boothroyd, Ph.D.	293	Discussion before The Institution	463
Design Considerations of Junction-Transistor Oscillators for the Conversion of Power from Direct to Alternating Current. F. Oakes	307	Photo-Electric Cells (Review of Progress). Prof. J. D. McGee, O.B.E., M.Sc., Ph.D.	467
Minority-Carrier Storage in Semi-Conductor Diodes. J. C. Henderson, B.Sc., and J. R. Tillman, D.Sc., Ph.D.	318	Measurements of Efficiency of Bolometer and Thermistor Mounts by Impedance Methods. J. A. Lane, M.Sc.	485
Discussion on the above three papers before the Radio and Telecommunication Section	333	Growth of Anode-to-Grid Capacitance in Low-Voltage Receiving Valves. F. H. Reynolds, B.Sc.(Eng.), C. B. Johnson and M. W. Rogers	487
A New Method for the Detection of Thin Conducting Films in Thermionic Valves. F. H. Reynolds, B.Sc.(Eng.), and M. W. Rogers	337	The Electric Strength of Silicone Liquids. T. J. Lewis, M.Sc., Ph.D.	493
Discussion on 'Computer Input and Output, including Analogue-Digital Conversion' (Authors' reply)	342	Discussion on 'The Instrumentation of a 14 in. Experimental Rolling Mill' (Paper by S. S. Carlisle and G. W. Alderton), before the North-Eastern Radio and Measurement Group	497
An Experimental Study of High-Permeability Nickel-Iron Alloys. C. E. Richards, E. V. Walker, B.Sc., and A. C. Lynch, M.A., B.Sc.	343	Influence of Argon Content on the Characteristics of Glow-Discharge Tubes. F. A. Benson, D.Eng., Ph.D., and E. F. F. Gillespie, M.Eng.	498
Discussion before the Measurement and Control Section	354	An Automatic Smith Diagram Display Unit for Use at Low Power Levels. H. V. Shurmer, M.Sc., Ph.D.	507
A Method for the Precise Measurement of Permittivity of Sheet Specimens. A. C. Lynch, M.A., B.Sc.	359	A Method of Estimating the Power radiated directly at the Feed of a Dielectric-Rod Aerial. R. H. Clarke, B.Sc.(Eng.)	511
A Bridge Network for the Precise Measurement of Direct Capacitance. A. C. Lynch, M.A., B.Sc.	363	The Electrical Characteristics of a Nickel-Chromium-Aluminium-Copper Resistance Wire. C. Dean Starr, Ph.D., and T. P. Wang, Ph.D.	515
Discussion on the above two papers before the Measurement and Control Section	366	The Measurement of Thermal and similar Radiations at Millimetre Wavelengths. G. R. Nicoll, B.Sc.	519
A Simple Transformer Bridge for the Measurement of Transistor Characteristics. W. F. Lovering, M.Sc., and D. B. Britten, B.E.	368	Discussion (<i>communicated</i>) on 'Design of Microwave Filters with Quarter-Wave Couplings' (Paper by G. Craven and L. Lewin)	528
Discussion before the Measurement and Control Section	373	The Remote and Automatic Control of Semi-Attended Broadcasting Transmitters. R. T. B. Wynn, C.B.E., M.A., and F. A. Peachey	529
The Capacitance between Diode Electrodes in the Presence of Space Charges. C. S. Bull, Ph.D.	374	The Design of High- and Low-Power Medium-Frequency Broadcasting Transmitters for Automatic and Semi-Attended Operation. W. J. Morcom, B.Sc.(Eng.), Wh.Sc., and D. F. Bowers	540
Discussion (<i>communicated</i>)	598	Discussion on the above two papers before the Radio and Telecommunication Section	549
The Ultimate Performance of the Single-Trace High-Speed Oscillograph. M. E. Haine, M.Sc., and M. W. Jervis, M.Sc.Tech.	379	Discussion on V.H.F. Broadcasting Technique (Paper by E. W. Hayes and H. Page)	553
The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed. M. E. Haine, M.Sc., and M. W. Jervis, M.Sc.Tech.	385	Thermal Turnover in Germanium <i>p-n</i> Junctions. A. W. Matz, M.Sc.	555
Discussion on the above two papers before the Joint Meeting of the Measurement and Control Section and the Radio and Telecommunication Section	390	Transistor Circuits and Applications. A. G. Milnes, D.Sc.	565
A Study of High-Speed Avalanche Transistors. J. R. A. Beale, B.A., W. L. Stephenson, B.Sc., and E. Wolfendale, B.Sc.	394	Discussion before the Radio and Telecommunication Section	581
Propagation of the Circular H_{01} Low-Loss Wave Mode around Bends in Tubular Metal Waveguide. Prof. H. E. M. Barlow, Ph.D., B.Sc.(Eng.)	403	Discussion on 'Transistor Power Amplifiers' (Paper by R. A. Hilbourne and D. D. Jones), and 'Transistor D.C. Converters' (Paper by L. H. Light and P. M. Hooker), before the Western Centre	585
The Design and Operation of High-Power Triodes for Radio-Frequency Heating. W. J. Pohl, M.Sc.	410	Discussion (<i>communicated</i>) on 'A New Form of Hybrid Junction for Microwave Frequencies' (Paper by P. D. Lomer and J. W. Crompton)	586
The 'Stereosonic' Recording and Reproducing System. H. A. M. Clark, B.Sc.(Eng.), G. F. Dutton, Ph.D., B.Sc.(Eng.), and P. B. Vanderlyn	417	The Frequency-Lock A.F.C. Circuit. R. Leek, B.Sc.(Eng.)	587
Discussion before the Radio and Telecommunication Section	430	Characteristics of some Ferrous and Non-Ferrous Waveguides at 27 Gc/s. J. Allison, B.Sc.(Eng.), Ph.D., F. A. Benson, D.Eng., Ph.D., and M. S. Seaman, B.Eng.	599
An Analogue Computer for Nuclear Power Studies. G. J. R. MacLusky, B.Sc.	433	Discussion on 'The Control and Instrumentation of a Nuclear Reactor' (Paper by A. B. Gillespie), before the North-Eastern Centre	602
The Application of Analogue Methods to Compute and Predict Xenon Poisoning in a High-Flux Nuclear Reactor. G. J. R. MacLusky, B.Sc.	443	Index	605

CONTENTS

v

PAGES IN PART B, 1957

Pages	No.	Month
1-72	13	January
73-196	14	March
197-340	15	May
341-416	16	July
417-528	17	September
529-604	18	November

CORRIGENDA TO VOL. 103, PART B SUPPLEMENT No. 2, 1956

Page 353: References 2, 7 and 8 *should read*:

- (2) BUSLIK, W. S.: 'I.B.M. Magnetic Tape Reader and Recorder', Review of Input and Output Equipment used in Computing Systems, Joint A.I.E.E.-I.R.E.-A.C.M. Computer Conference, December, 1952, p. 86.
- (7) WALLACE, R. L., JR.: 'The Reproduction of Magnetically Recorded Signals', *Bell System Technical Journal*, 1951, 30, p. 1145.
- (8) BEGUN, S. J.: 'Magnetic Recording' (Murray Hill, New York, 1949).

CORRIGENDA TO VOL. 104, PART B, 1957

Page 406: On Fig. 2, the scale of the ordinate should be multiplied by 10^2 , not 10^4 .

On Fig. 3, the scale of the ordinate should be multiplied by 10^2 .

Declaration on Fair Copying.—Within the terms of the Royal Society's Declaration on Fair Copying, to which The Institution subscribes, material may be copied from issues of the *Proceedings* (prior to 1949, the *Journal*) which are out of print and from which reprints are not available. The terms of the Declaration and particulars of a Photoprint Service afforded by the Science Museum Library, London, are published in the *Journal* from time to time.

Bibliographical References.—It is requested that bibliographical reference to an Institution paper should always include the serial number of the paper and the month and year of publication, which will be found at the top right-hand corner of the first page of the paper. This information should precede the reference to the Volume and Part.

Example.—SMITH, J.: 'Reflections from the Ionosphere', *Proceedings I.E.E.*, Paper No. 3001 R, December, 1954 (102 B, p. 1234).

REPORT
ON THE PROGRESS OF THE
WORK DURING THE YEAR 1887

The work of the year has been devoted to the study of the history of the
country, and to the collection of materials for the history of the
people. The first part of the year was spent in the study of the
history of the country, and the second part in the collection of
materials for the history of the people. The work has been
devoted to the study of the history of the country, and to the
collection of materials for the history of the people. The work
has been devoted to the study of the history of the country, and
to the collection of materials for the history of the people. The
work has been devoted to the study of the history of the country,
and to the collection of materials for the history of the people.